253850-5-0

Final Briefing
RETRIEVAL, DISPLAY, AND ANALYSIS SUPPORT TOOL FOR EARTH IMAGERY (RDAST)

R. C. Anderson
C. C. Chiesa
W. A. Tyler

September 1994

Submitted to:
Defense Technical Information Center
Cameron Station, Room 5B205
Alexandria, VA 22304-6145

Attn: Dr. Forrest R. Frank

Contract Number: DLA900-88-D-0392, D.O. #52

ERIM
P.O. Box 134001
Ann Arbor, MI 48113-4001

ERIM-320

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave Blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1994	Final

4. TITLE AND SUBTITLE
Final Briefing
Retrieval, Display, and Analysis Support Tool for Earth Imagery (RDAST)

5. FUNDING NUMBERS
DLA900-88-D-0392/0052

6. AUTHOR(S)
R. C. Anderson
C. C. Chiesa
W. A. Tyler

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Environmental Research Institute of Michigan
P.O. Box 134001
Ann Arbor, Michigan 48113-4001

8. PERFORMING ORGANIZATION REPORT NUMBER
253850-5-0

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Defense Technical Information Center
DTIC-AI
Bldg. 5, Cameron Station
Alexandria, VA 22304-6145

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Hardcopy of presentation

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)
The Retrieval, Display, and Analysis Support Tool (RDAST) is a system designed to facilitate access to the wide variety of available earth imagery. Using the ARC/INFO geographic information system, RDAST converts user requirements into specific sensor parameters and searches internal and external databases for the availability of suitable imagery. Sample imagery are displayed. The current implementation is based on public systems (LANDSAT, SPOT, and several airborne collections, but is not limited to this.
This document contains viewgraphs from the final briefing for this program.

14. SUBJECT TERMS
Earth observation
Image understanding
Infrared Technology
LANDSAT
SPOT

15. NUMBER OF PAGES
68

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

INFRARED INFORMATION ANALYSIS CENTER

Retrieval, Display, and Analysis Support Tool for Earth Imagery (RDAST)

ERIM

RDAST Final Briefing

--

13 September 1994
Environmental Research Institute of Michigan
Arlington, VA

INFRARED INFORMATION ANALYSIS CENTER

Retrieval, Display, and Analysis Support Tool for Earth Imagery (RDAST)

ERIM

Agenda

Project Overview	**Rod Anderson**	**1000**
Sensor Data Comparison	**Bill Tyler**	**1015**
RDAST System	**Chris Chiesa**	
System overview		**1100**
Demonstration		**1130**
Discussion	**All**	**1145**
Adjorn		**1200**

Program Overview

Contract number: DLA 900-88-D0392 DO 052

Program Objectives: Develop tools to index, search and compile available imagery of the earth's surface for military and dual use purposes.

Period of Performance: 9/28/93 -8/27/93 (with extension)

Milestones:

Planning meeting:	19 Jan 1994
Interim briefing:	31 Mar 1994
Final briefing:	13 Sep 1994

Obstacles to Efficient Use of Available Datasets

- Sheer numbers of satellites, sensors, and observations have hampered a systematic assessment of the utility of various combinations.
- Data and sensor fusion techniques have been insufficiently mature to extract useful information from disparate data sets.
- Fusion techniques require extensive knowledge of sensor parameters and ground truth.
- National security considerations limit access to certain data sets.
- Requirements on information content and data extraction methods differ greatly with user needs.

INFRARED INFORMATION ANALYSIS CENTER

Retrieval, Display, and Analysis Support Tool for Earth Imagery (RDAST)

ERIM

RDAST Approach

- **Task 1: Image Identification and Compilation**
  - Identify sources of earth imagery from airborne and space-based sensors
  - Develop indexing schemes that identify imagery available of earth scenes
  - Compile "Metadata" each included sensor mode

- **Task 2: Image Evaluation**
  - Develop measures of image goodness, based on user requirements
  - Characterize the quality of image sets using ground truth and other measures
  - Develop a system for consistent annotation of selected images

- **Task 3. Coordination and Requirements Development**
  - Identify specific user groups to use as benchmarks in requirements development
  - Assess group needs and derive requirements
  - Review and assess features of existing data archiving and retrieval systems.

- **Task 4. Sensor Data Comparison**
  - Select two space-based or airborne sensors
  - Display the extraction of information using data and sensor fusion techniques
  - illustrate multiple phenomenology representations

RDAST

Data Base Development and Demonstration

ERIM

13 September 1994

Retrieval, Display and Analysis Support Tool

Christopher C. Chiesa
Environmental Research Institute of Michigan
Ann Arbor, MI 48105
(313) 994-1200 ext. 3791
chiesa@erim.org

Presentation Overview

- Task Background & Overview
- RDAST Data Base Description
- RDAST Prototype System Demonstration

Task Objectives:

Design and Implement Electronic Data Base for Storage, Retrieval and Display of Primary and Metadata for Airborne and Spaceborne Remote Sensing Systems.

Data Base Requirements

- **Provide Local Data Management Capabilities including Storage, Query, Retrieval and Display of Remotely-Sensed Imagery**
- **Store/Query/Retrieve Sensor Metadata**
- **Link to External Archives/Catalog Systems**

Data Base Design

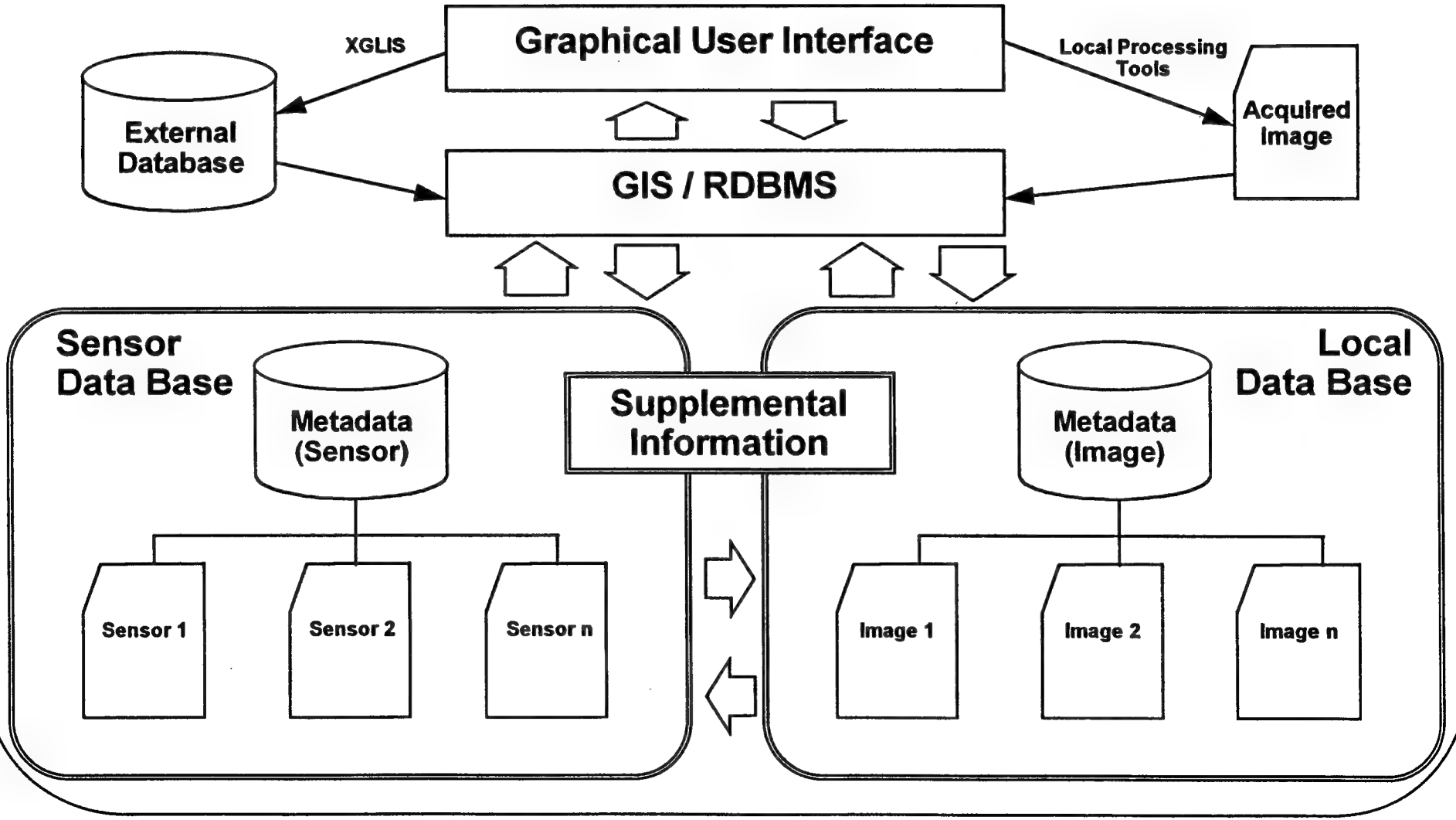
- GIS/RDBMS-Based
- Sensor Data Base
  - Metadata
  - Sample Data Sets
  - Supplementary Information
- Local Data Base
  - Metadata
  - Inventory (Images)
- External Archive Search Linkage
  - XGLIS (EDC)

RDAST

Data Base Development and Demonstration

ERIM

Data Base Design



Data Base Description

- **Sensor Database Tables**
  - SENSORBANDS: Describes RDAST sensors/platform/band info
  - BANDSTYPS: Lists valid band types
  - PLATFORMS: Lists valid image platforms
  - PLATFORMTYPS: Lists platform types (e.g. SAT/ACFT)
  - SENSORTYPS: Lists valid sensor types
  - SENSORS: Lists RDAST sensors
  - SENSORSAMPLES: Lists sample image for each sensor
- **Image Database Tables**
  - IMAGEDEFS: Describes local and sample images
  - IMAGEBANDS: Lists bands processed for each local/sample image
  - IMAGEDOCS: Lists Hypertext documents related to lcl./smpl. imgs.
  - IMAGEPROJECPARAMS: Lists projection params. for l/s imgs.
- **Support Database Tables**

Data Base Description - IMAGEDEF Table

4.0 IMAGEDEF

This table is used to describe the local/sample images. Certain fields in this table are platform specific and may be left blank.

Database Table: IMAGEDEF

Table Field Name	Format	Use	Description	Validation	Cross-Reference Tables
IMAGEID	Char 30	Primary Key	The image identification name.	Uppercase. Not Null. Unique ID/ SHELF key.	IMAGEBANDS IMAGEDOCS IMAGEPROJ-PARAMS SENSORSAMPLES
IMAGESHELF	Char 11	Primary Key	The unique shelf location for the image (or image name).	Uppercase. Not Null. Unique ID/ SHELF key.	IMAGEBANDS IMAGEDOCS IMAGEPROJ PARAMS SENSORSAMPLES
IMAGEDATE	Date		The date of image acquisition. In the case of a mosaic image, choose a date that most fits the image.	Format DD/MM/ YY.	
SEASON	Char 6		The season that this image was acquired. (automatically calculated from imagedate when the record is added or updated from liupdate).	Must be one of: SPRING SUM-MER, AUTUMN, WIN-TER	
TITLE	Char 50		A descriptive title for the image.		
SECURITY_CLASS	Char 1	Foreign Key	The security classification of the image. Must be a valid classification as defined in the validclass table.	Uppercase. Not Null.	VALIDCLASS

Data Base Description - IMAGEDEF Table

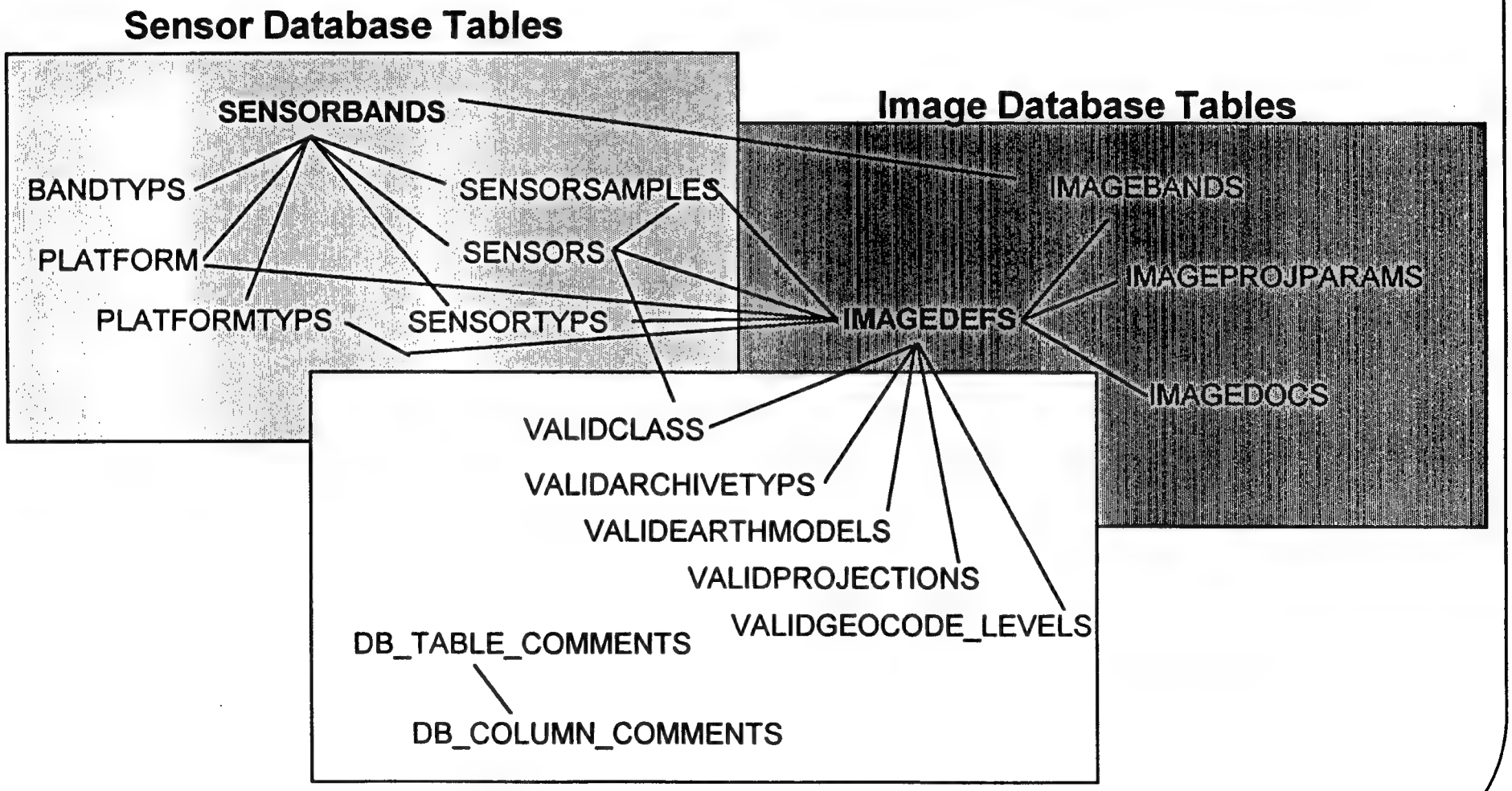
Table Field Name	Format	Use	Description	Validation	Cross-Reference Tables
SENSOR	Char 10	Foreign Key	The sensor from which the image originated.	Not Null. Must be a valid sensor from the SENSORS table.	SENSORS SENSORBANDS SENSORSAMPLES
PLATFORM	Char 10	Foreign Key	The platform from which the image originated.	Not Null. Must be a valid sensor from the PLATFORMS table.	PLATFORMS SENSORBANDS
SENSORTYP	Char 10	Foreign Key	The sensor type from which the image originated.	Not Null. Must be a valid type for the sensor - from the SENSORS table.	SENSORS SENSORTYPS SENSORBANDS SENSORSAMPLES
PLATFORMTYP	Char 10	Foreign Key	The platform type from which the image originated.	Not Null. Must be a valid type for the platform - from the PLATFORMS table.	PLATFORMS PLATFORMTYPS SENSORBANDS
ARCHIVETYP	Char 20	Foreign Key	The type of media of the image (e.g. 9-TRACK, CD-ROM). Must be a valid type as defined in the validarchivetyps table.	Must be validated against the VALIDARCHIVETYHPS table.	VALIDARCHIVETYPS
GEOCODE_LEVEL	Number 1	Foreign Key	The geocode/reference level of the image. Must be a valid level as defined in the validgeocode_levels table.	Must be validated against the VALIDGEOCODE_LEVELS table.	VAKIDGEOCODE_LEVELS
CELLSIZE_X	Number 5		The cell size in the X direction (DX).		

RDAST

Data Base Development and Demonstration

ERIM

Data Base Entity Relationship



Data Base Implementation

- ARC/INFO Geographic Information System (GIS)
- ARC Macro Language (AML) Graphical User Interface (GUI)
- ARC/INFO Data Structures
  - INFO Tables ..... Metadata
  - Raster ..... Images
  - Topological Vector ... Boundary/Reference
- Supplemental (Guide) Sensor Information
  - Frame View Hypertext

Operational Scenario (Sample)

- Situation Requiring Remotely Sensed Data Arises
- Query RDAST to Determine Necessary and Suitable Image Sources
- Local Data Base Searched for Availability of Imagery
- External Archive Searched for Availability of Imagery
- Data Acquired, Processed and Archived (Local DB)

RDAST Demonstration

13 September 1994

RETRIEVAL, DISPLAY, AND ANALYSIS TOOL FOR EARTH IMAGERY

Task 4: Sensor Data Comparison

William A. Tyler
Environmental Research Institute of Michigan
Ann Arbor, MI 48113
tyler@vaxa.erim.org

Task 4 - Sensor Data Comparison Image Examples

TASK OBJECTIVE: To Demonstrate the Utility of Using Commercial Space-Based and Airborne Sensors to Exploit Image data Using Information Extraction and Sensor Fusion Techniques

Commercially Available Satellite Data

- SPOT (XS and Pan) ✓✓
- Landsat (MSS and TM) ✓✓
- AVHRR (LAC and GAC)
- JERS-1 (Optical and Microwave)
- ERS-1
- CZCS
- KFA (image or digital)

Other Sources of Image Data

- Airborne Multispectral Scanners (M7) ✓
- Airborne Imaging RADAR Sensors (IFSARE)
- Aerial Photography

Obtainable Ancillary Data

- Large Scale Topographic Maps
- Digital Elevation Models (for some parts of the World)
- Digital Chart of the World (DCW)
- Scanned Navigational Charts

Task 4 - Sensor Data Comparison Image Examples

By Combining Commercial Remote Sensing Images With Available Ancillary Data, Information Products May Be Generated

Examples of Satellite-Derived Information Products

- Cartographically Accurate Image Maps
- Derived Images such as Categorized Images, Bathymetric Images, Enhanced Images
- Fused Image Products such as Perspective Views, Pan-Sharpened Multispectral Data, Change Images

Information Products Generated During Task 4 Activities

- Portions of the RDAST Data Base Were Populated With Examples of Commercially Available Data
- Examples of Landsat MSS, TM, SPOT and SPOT-Sharpened Image Data Were Generated For a Variety of Geographic Areas
- A Perspective View Flythrough Loop was Produced for the RDAST Data Base
- Examples of Other Image-Derived Products were Generated: Data Fusion Examples, Change Detection, Terrain Categorization, and Spot-Sharpened TM

Digital Files Generated for RDAST Data Base

- Ann Arbor Data (M7, TM, MSS, AVHRR)
- Chambery Data (TM, MSS, DTED, Fly-Through)
- Baghdad Data (2 TM)
- St. Charles Flood (2 TM, Spectral Features)
- Washington, D.C. (SPOT, TM, Sharpened)

Important Dates in Commercial Remote Sensing

- July 1972 - October 1992, **Landsat MSS** Data Available
- July 1982 - Present, **Landsat TM** Data Available
- February 1986 - Present, **Spot** Data Available
- October 1979 - Present, **AVHRR** Data Available

Pixels per Millimeter at Various Scales and Spatial Resolution

Sensor	1:250,000	1:100,000	1:50,000	1:25,000
AVHRR	0.25	0.1	0.05	0.025
MSS	5.0	2.0	1.0	0.5
TM	10.0	4.0	2.0	1.0
SPOT-XS (20m)	12.5	5.0	2.5	1.25
SPOT-Pan (10m)	25.0	10.0	5.0	2.5

Pixels per Square Kilometer for Various Satellite Sensors

Sensor	Resolution	Pixels/sq.km	Bands	Total Pixels/sq km
AVHRR	1,100 m (nadir)	0.9	5	4.5
MSS	80 meters	226	4	904
TM	30 meters	1,231	7	8,617
SPOT-XS (20m)	20 meters	2,500	3	7,500
SPOT-Pan (10m)	10 meters	10,000	1	10,000

The SPOT Satellite System (SPOT 1 - 3)

- SPOT Acronym: *Systeme Pour l'Observation de la Terre*
- Development of the SPOT System
  - launch facility in South America
  - CNES: *Centre National d'Etudes Spatiales* (like NASA in the U.S.)
  - Toulouse: SPOT Image Headquarters
- SICORP
  - U.S. Distributor of SPOT Data

The HRV (*Haut Resolution, Visible*) Sensor

- Pushbroom Design: No Moving Parts
- Spectral Resolution
  - panchromatic mode 0.51-0.73 μm
  - XS mode, 3 bands 0.50-0.89 μm
- Spatial Resolution
  - panchromatic mode 10 m
  - XS mode 20 m

SPOT Satellite Orbit

- Sun Synchronous
- Near Polar
- Overpass Time: 10:30 AM at Equator
- Off-Nadir Viewing
  - Advantages: Rapid Revisit (2.5 days on average), Stereo Coverage Possible
  - Disadvantages: More Complex Geometric Correction Algorithms

SPOT Scene Geometry

- Nominal SPOT Frame Size 60 x 60 km
- Off-Nadir: up to 80 x 60 km
- Number of Pixels
  - panchromatic mode: 6,000 x 6,000
  - XS mode: 3,000 x 3,000 x 3 bands

Memory Requirements

- SPOT Pan scene: 6,000 x 6,000 = 36 Mbytes per scene
- SPOT XS scene: 3,000 x 3,000 x 3 = 27 Mbytes per scene
- One degree x One degree Area: 6 - 8 SPOT scenes required

Satellite Locator Map

- GRS sheets: *(Grille de Reference SPOT)* map series @ 1:5,000,000 scale showing scene center locations
- K/J Coordinates
  - "K" coordinates along track of satellite
  - "J" coordinates analogous to lines of latitude (equator J>350)

The Landsat Satellite System

- Landsat 1 Launched in July 1972
  - carried Return Beam Vidicon (RBV) and Multispectral Scanner (MSS)
  - Landsats 2 & 3 carried same two sensors
- Landsat 4 Launched in July 1982
  - carried Thematic Mapper (TM) and Multispectral Scanner (MSS)
  - Landsat 5, launched in March 1984, carried same two sensors

The Multispectral Scanner

- Spatial Resolution Approximately 80 meters
- Spectral Resolution: 4 Broad Spectral Bands from 0.5 - 1.1μm
- Radiometric Resolution: 6-bits/pixel/band

The Thematic Mapper

- Spatial Resolution 30 meters
- Spectral Resolution: 6 Spectral Bands from 0.45 - 2.35μm, plus one thermal band
- Radiometric Resolution: 8-bits/pixel/band

Landsat Satellite Orbit

- Sun Synchronous
- Near Polar
- Overpass Time: 9:30 AM at Equator
- Revisit Every 16 Days (18 days for Landsat 1-3)

Landsat Scene Geometry

- Landsat Scene 185 x 185 km
- Amount of Sidelap Varies with Latitude
- Number of Pixels
  - nominal size 5965 rows x 6967 columns (41.56 Mbytes/band)

Landsat Scene Storage Requirements

- Landsat TM scene: 5,965 x 6,967 = 41.56 Mbytes per band
- Full Frame: 5,965 x 6,967 x 7 = 291 Mbytes
- MSS data: 2300 x 3264 x 4 = 30 Mbytes
- One degree x One degree Area: 1 - 4 Landsat scenes required

Ann Arbor, Michigan

- M7 Data for Willow Run Airport (geocoded)
- Landsat MSS Data From August 1990 (geocoded)
- Landsat TM Data From May 1992 (geocoded)

Chambery, France

- Landsat MSS Data From May 1976 (geocoded)
- Landsat TM Data From July 1984 (geocoded)
- Digital Elevation Model Generated from 3 Arc-Second DTED Data
- Animated Fly-Through Sequence Produced

Baghdad, Iraq

- Landsat TM Data From January 1990
  (geocoded using satellite ephemeris)
- Landsat TM Data From January 1991
  (geocoded using satellite ephemeris)

St. Charles, Missouri

- Landsat TM Data From 15 July 1986, Geocoded, Pre-Flood Data
- Landsat TM Data From 18 July 1993, Geocoded, Flood Near Peak
- Various Derived Images (Flood Extent, Flooded Agricultural Land, etc.)

Summary

- Commercial Satellite are Data Available For Most of the World at a Variety of Resolutions
- SPOT Data (10m spatial resolution) Useful at Scales as Large as 1:20,000
- Landsat TM Data (30m) Useful at Scales as Large as 1:50,000
- Commercial Data May Be Used To Derive a Variety of Information Products

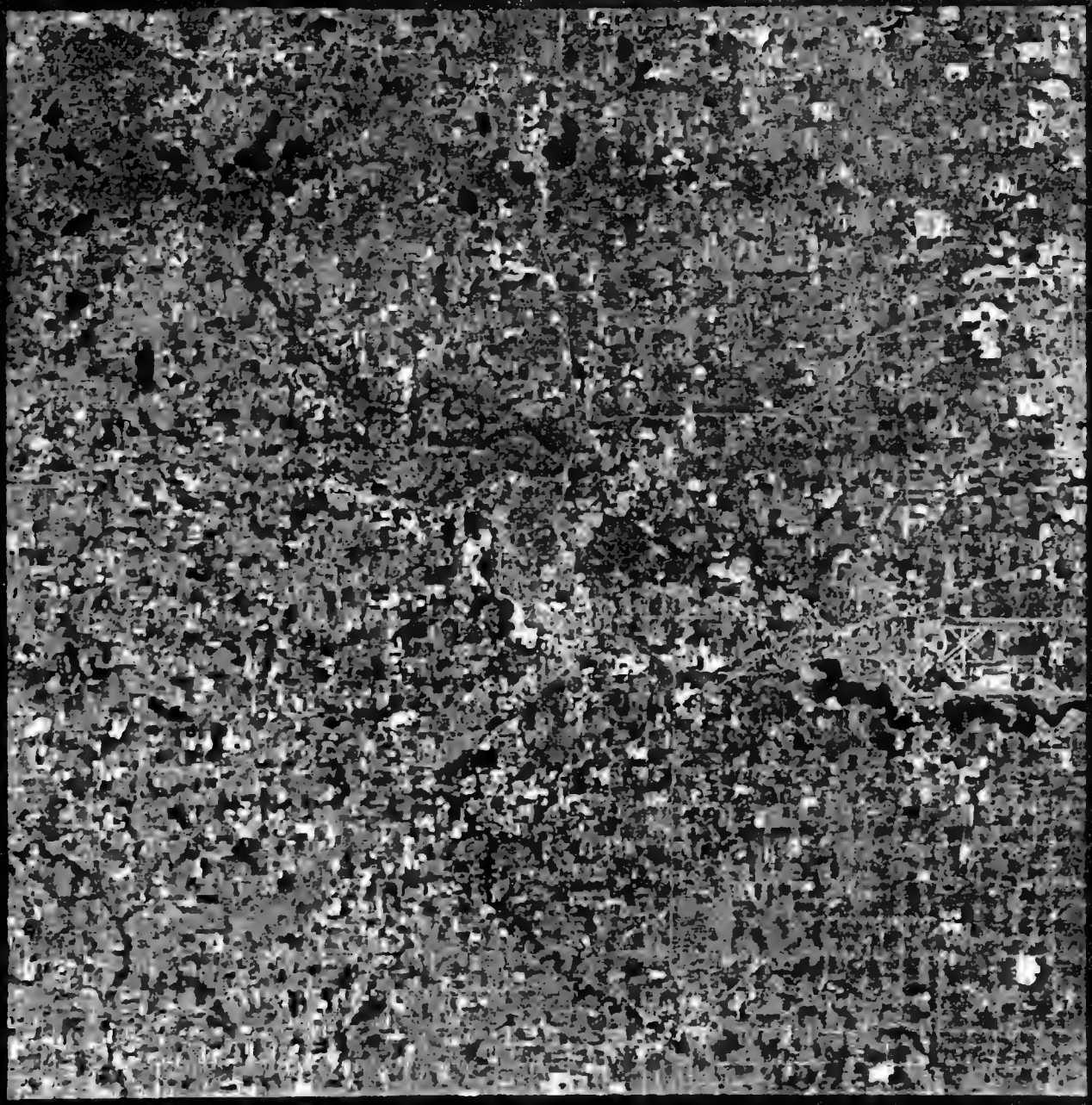
Ann Arbor, Michigan

Landsat Thematic Mapper (TM) Data, Partial Scene
False Color Composite
Bands 4 3 2 / R G B
Path 20 Row 30
Scene Date: 16 May 1992

0 5 10 Kilometers

ERIM

Ann Arbor, Michigan

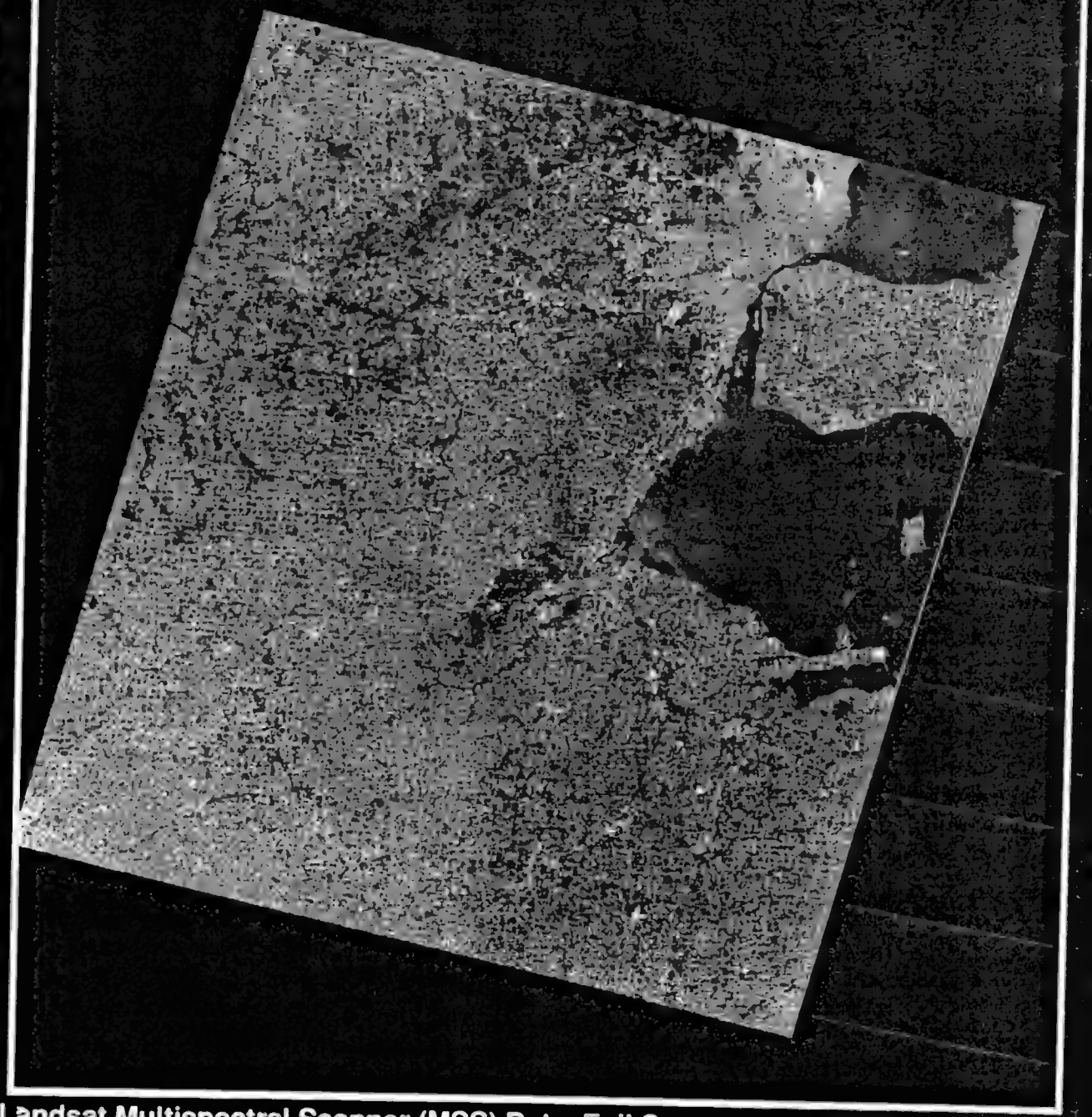


Landsat Multispectral Scanner (MSS) Data, Partial Scene
False Color Composite
Bands 4 2 1 / R G B
Path 20 Row 31
Scene Date: 31 August 1990

0 5 10 Kilometers

ERIM

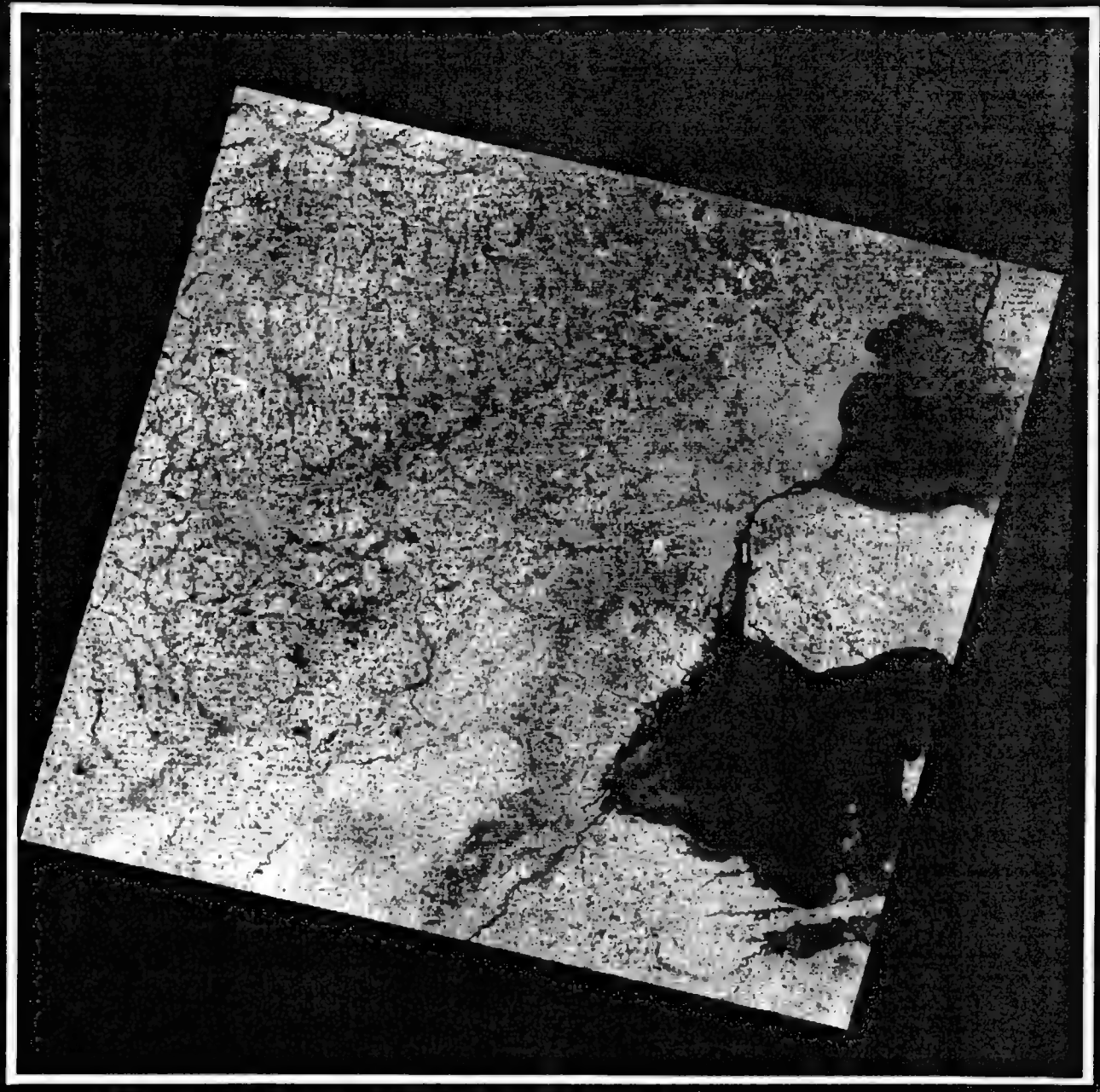
Ann Arbor, Michigan



Landsat Multispectral Scanner (MSS) Data, Full Scene
False Color Composite
Bands 4 2 1 / R G B
Path 20 Row 31
Scene Date: 31 August 1990

ERIM

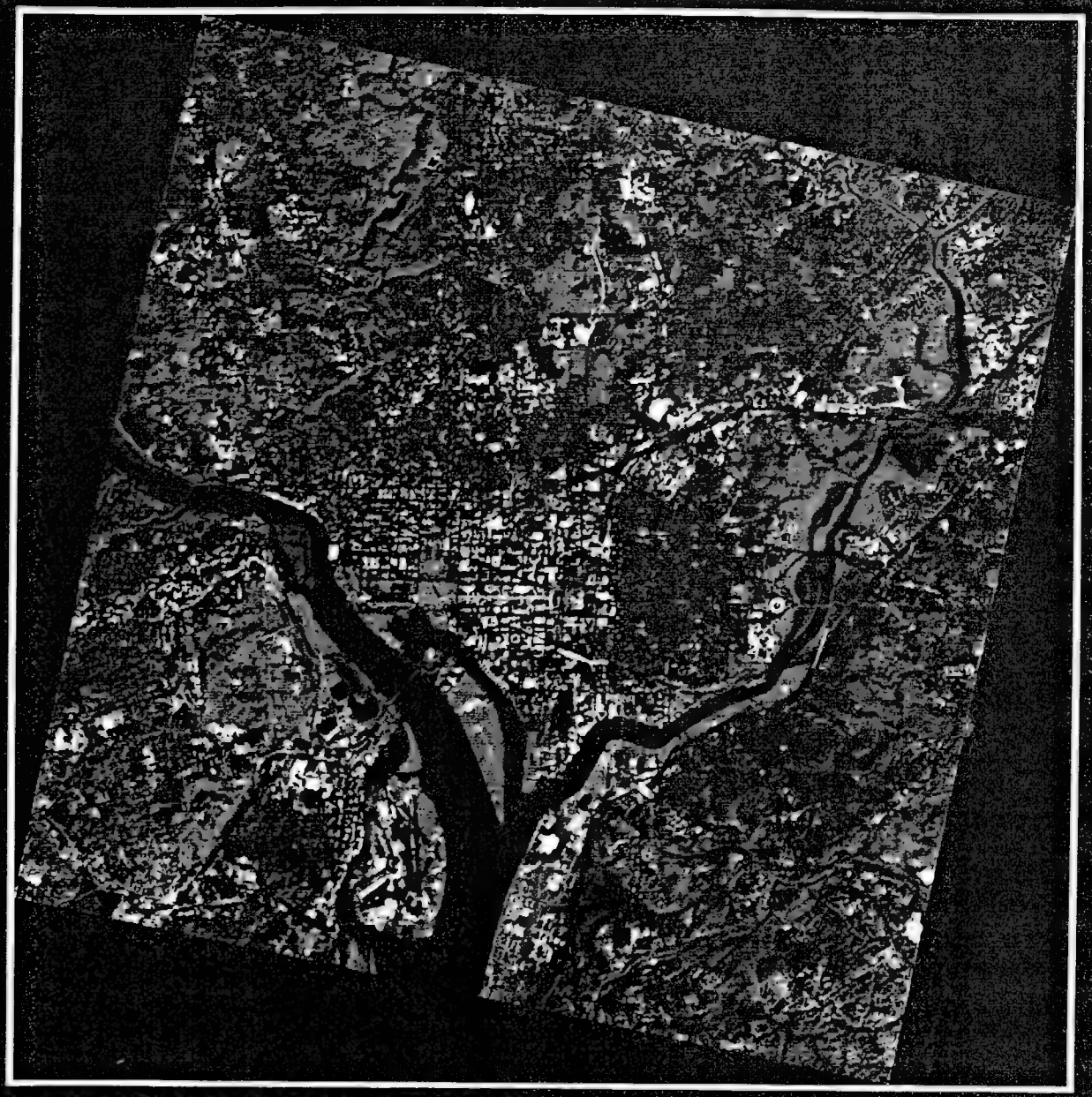
Ann Arbor, Michigan



Landsat Thematic Mapper (TM) Data, Full Scene
False Color Composite
Bands 4 3 2 / R G B
Path 20 Row 30
Scene Date: 16 May 1992

ERIM

Washington, D.C.



Landsat Thematic Mapper (TM) Data
False Color Composite
Bands 4 3 2 / R G B
Scene Date: 23 October 1993
Resampled to 20 m cells, UTM Projection

0 2 4 Kilometers

ERIM

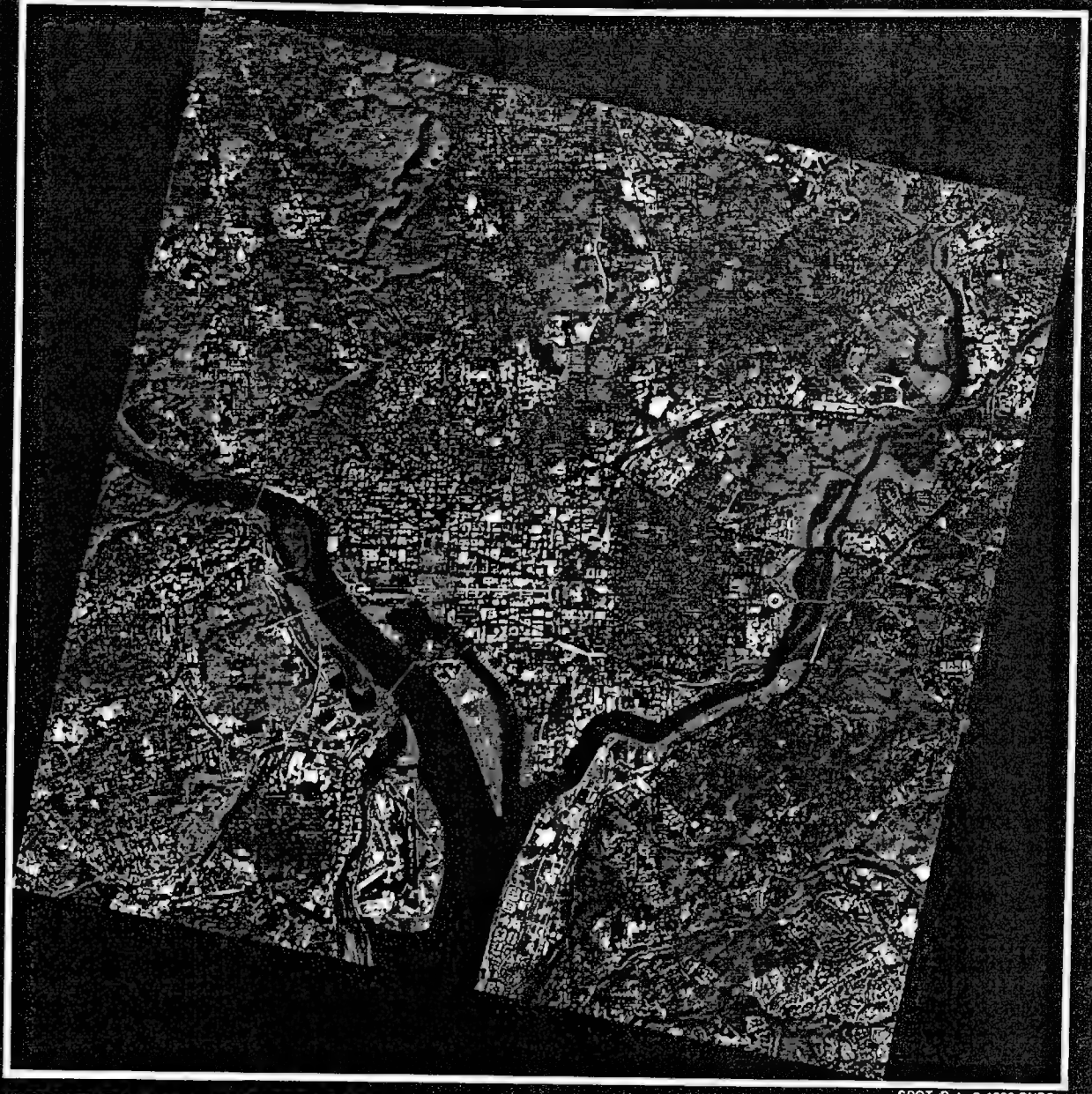
Washington, D.C.

SPOT Panchromatic Data
K 623 J 272
Scene Date: 28 September 1993
Resampled to 10 m cells, UTM Projection

0 2 4 Kilometers

ERIM

Washington, D.C.



SPOT Data © 1993 CNES

SPOT-Sharpened TM Data
SPOT Pan Data and TM Bands 432/RGB
SPOT Scene Date: 28 September 1993
TM Scene Date: 23 October 1993
Resampled to 10 m cells, UTM Projection
Sharpening Algorithm: SPARKLE

0 2 4 Kilometers

ERIM


St. Charles, Missouri
Flood Extent, 18 July 1993
Flood Mask (Red) Overlayed on Natural Color Image
0 2 4 Kilometers
Scene Date: 18 July 1993
ERIM

St. Charles, Missouri
Flooded Cultural Features

Water Feature 1986: Blue
Water Feature 1993: Green
Built-Up Land: Red

0 2 4 Kilometers

Interpretation Key:

Dark Blue = Flooded Areas
Magenta = Flooded Roads/ Parking Lots
White = Flooded Buildings
(if Surrounded by Blue)

ERIM

St. Charles, Missouri
Flooded Agriculture

Flooded Agricultural Land (Green) Overlayed on
Tasseled Cap Brightness Spectral Feature

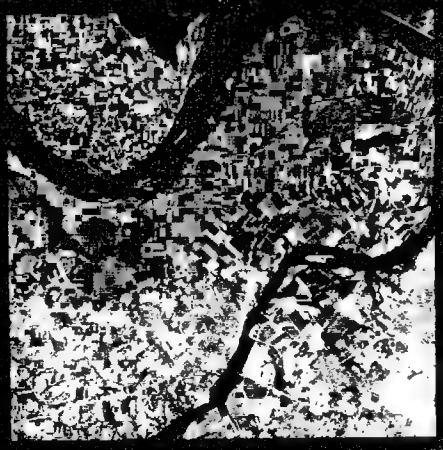
0 2 4 Kilometers

Scene Date: 18 July 1993

ERIM

St. Charles, Missouri

15 July 1986
Landsat TM Bands 321/RGB
(Natural Color Composite)



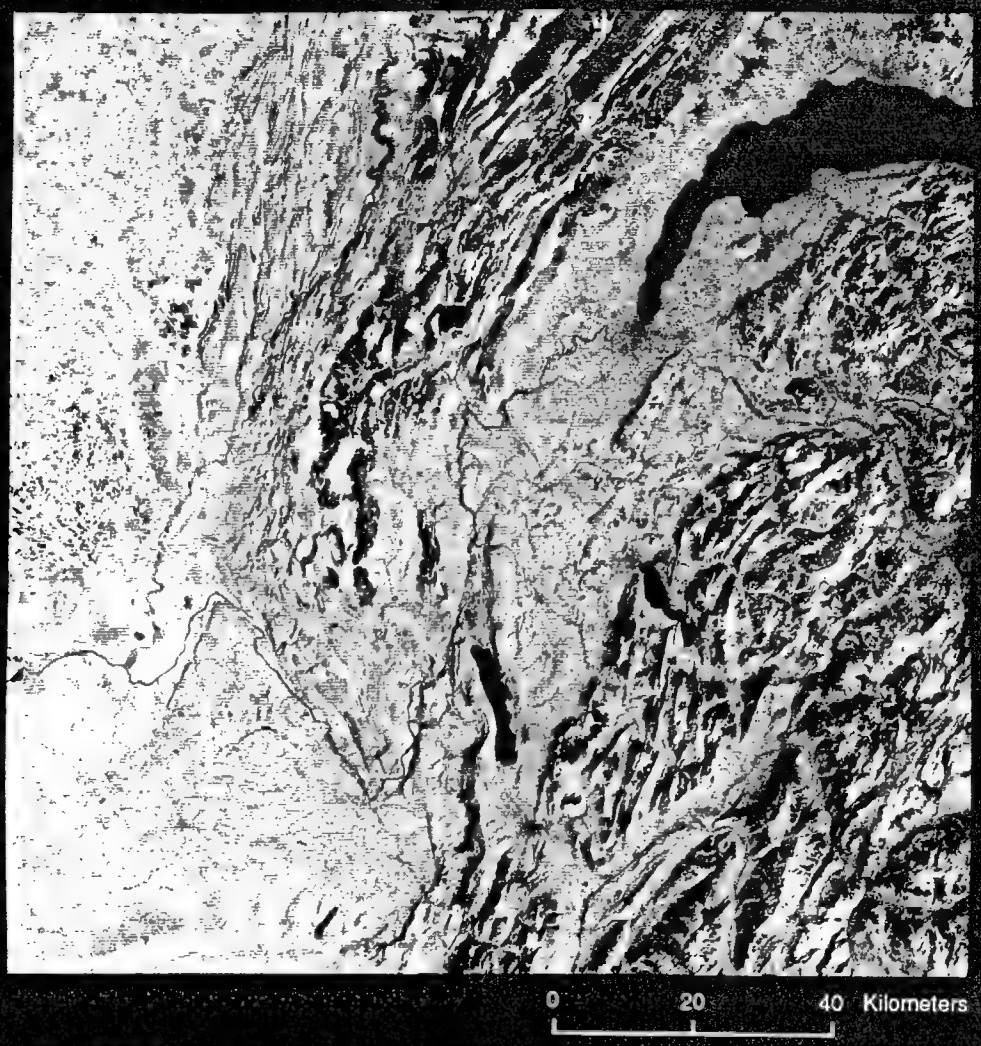
Water Feature

18 July 1993
Landsat TM Bands 321/RGB
(Natural Color Composite)

Water Feature

ERIM

Chambery, France



Landsat Thematic Mapper (TM) Data
False Color Composite
Bands 7 4 2 / R G B
Path 196 Row 28
Scene Date: 30 July 1984
Resampled to 25 m cells, Lambert Projection

ERIM

Chambery, France

0 10 20 Kilometers

Landsat Thematic Mapper (TM) Data, Partial Scene
Natural Color Composite
Bands 3 2 1 / R G B
Path 196 Row 28
Scene Date: 30 July 1984
Resampled to 25 m cells, Lambert Projection

ERIM

Perspective View Fly - Through

Frame 47

Frame 60

Frame 117

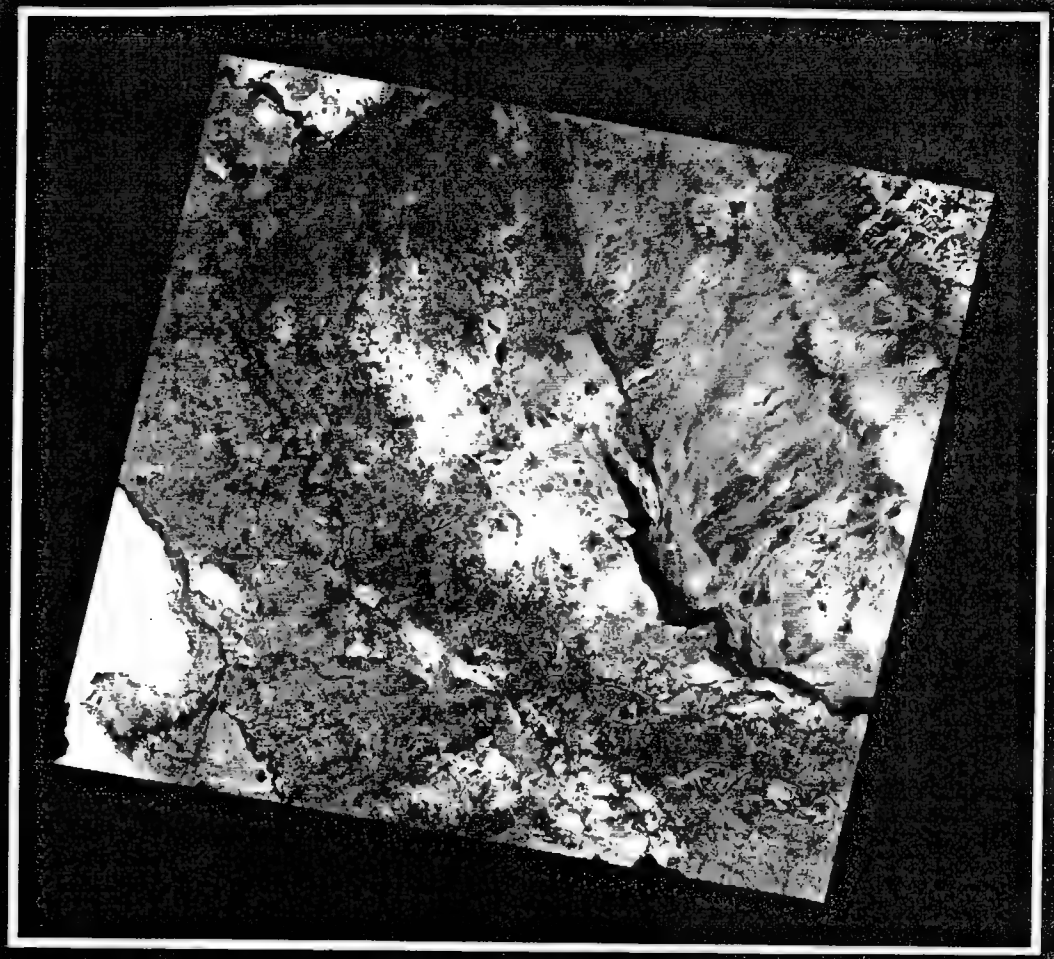
Frame 130

Landsat TM
Natural Color
Scene Date: 30 July 1984
Path/ Row: 196-28

3 Arc - Second DTED

ERIM

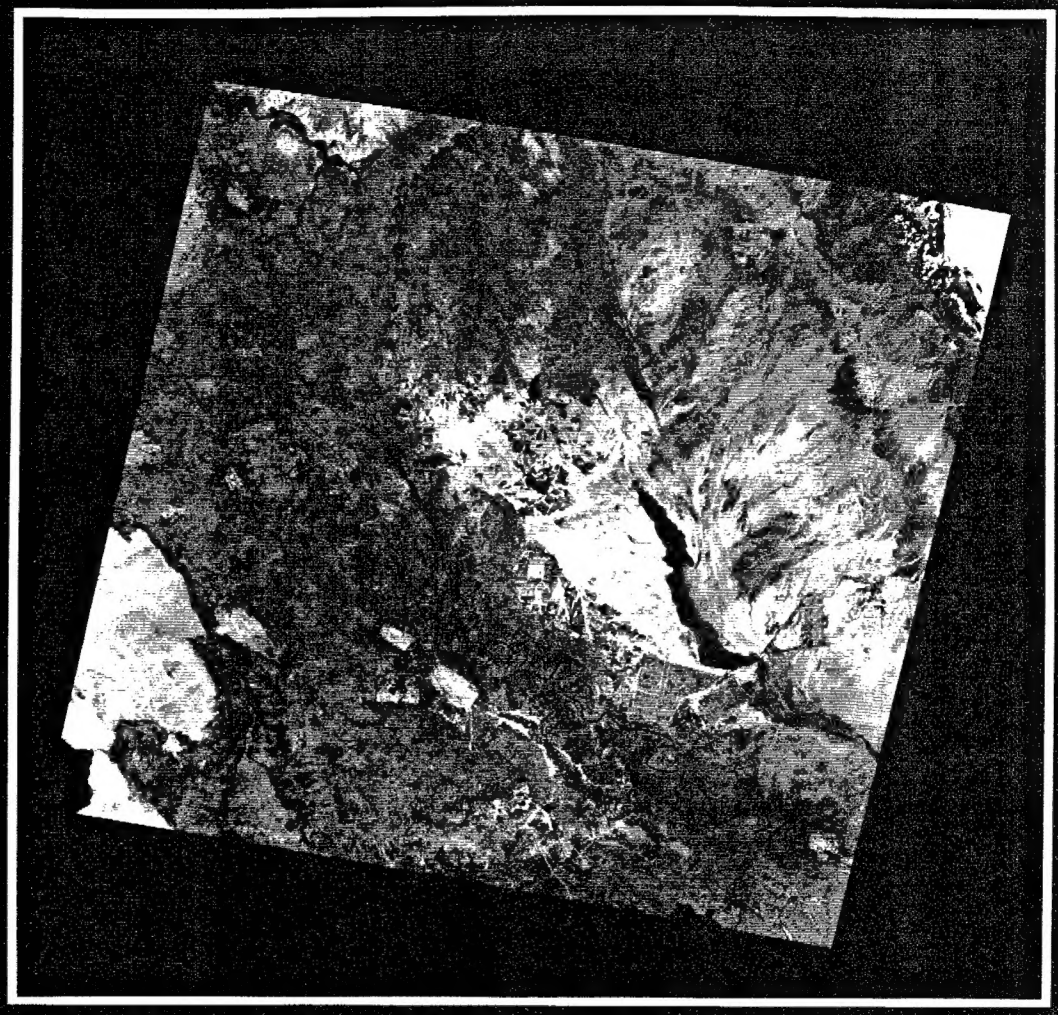
Baghdad, Iraq



Landsat Thematic Mapper (TM) Data, Full Scene
False Color Compoosite
Bands 7 4 2 / R G B
Path 168 Row 37
Scene Date: 8 January 1990
Resampled to 25 m cells, UTM Projection

ERIM

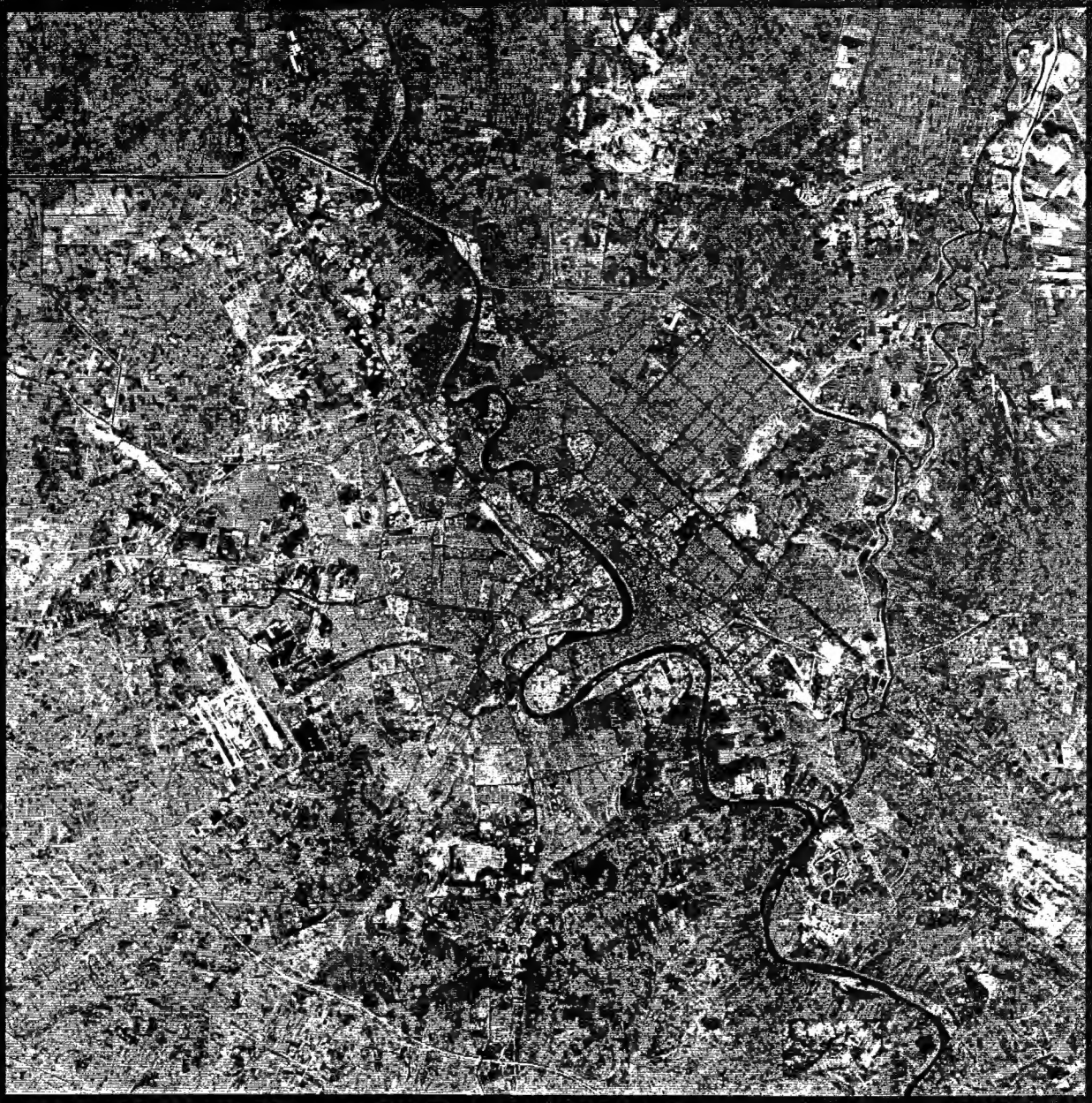
Baghdad, Iraq



Landsat Thematic Mapper (TM) Data, Full Scene
False Color Composite
Bands 7 4 2 / R G B
Path 168 Row 37
Scene Date: 27 January 1991
Resampled to 25 m cells, UTM Projection

ERIM

Baghdad and Environs



Landsat Thematic Mapper (TM) Data, Partial Scene
False Color Composite
Bands 7 4 2 / R G B
Path 168 Row 37
Scene Date: 8 January 1990
Resampled to 25 m cells, UTM Projection

0 5 10 Kilometers

ERIM

Baghdad and Environs

Landsat Thematic Mapper (TM) Data, Partial Scene
False Color Composite
Bands 7 4 2 / R G B
Path 168 Row 37
Scene Date: 27 January 1991
Resampled to 25 m cells, UTM Projection

0 5 10 Kilometers

ERIM

Spatial Filters
Baghdad, Iraq

Raw Data TM 742/RGB

Laplacian

11 x 11 Boxcar

51 x 51 Boxcar

Landsat TM Data
Scene Date: 8 Jan 1990
Path 168 Row 37

ERIM